Assessing the Vulnerability of Species and Ecosystems to Projected Future Climate Change in the Pacific Northwest

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Overview

To develop effective adaptive management plans, conservation and natural resource managers need to know how climate change will affect the species and ecosystems they manage. This project will provide managers with information about potential climate change effects on species and managed areas in the Pacific Northwest. We are evaluating projected changes in climate, vegetation, and species distributions through the year 2099 and assessing the potential impacts of these changes on key species and managed lands. We will work with conservation and natural resource managers to incorporate the results of this study into state, federal, and non-governmental organization (NGO) management plans. The projected changes in climate, vegetation, and species distributions will be summarized for the entire study region as well as for specific land management units, including national parks, state and federal fish and wildlife refuges, and The Nature Conservancy (TNC) owned and managed sites.

Objectives

Climate change is affecting the wildlife and habitats of the Pacific Northwest. Annual temperatures averaged across the region have increased by 0.8 °C over the period 1900-2000 (Mote et al. 2003, updated) and are projected to increase by 3.0 °C or more (compared with 1970-1999 values) by the end of the century (Mote and Salathé 2009). Annual precipitation averaged across the region has also increased over the period 1930-1995 relative to 1930 values (Mote et al. 2003). Future precipitation projections are more ambiguous, with some future projections simulating increased precipitation for the region and other projections simulating decreased precipitation (Mote and Salathé 2009).

This project is designed to assist managers in understanding the potential impacts of potential climate changes on the species and ecosystems they manage. It has six specific objectives:

1. Downscaling future climate simulations to high spatial resolution grids (e.g., 30 arc-second) of the Pacific Northwest.
2. Simulating potential future vegetation changes using dynamic vegetation models.
3. Modeling potential shifts in the distributions of 12 or more focal animal species chosen in consultation with managers.
4. Assessing the vulnerabilities of species and managed lands to future climate change.
5. Summarizing uncertainties in the simulated climate, vegetation, and species distribution changes.
6. Working in collaboration with managers to incorporate our research results into conservation and natural resource management plans.

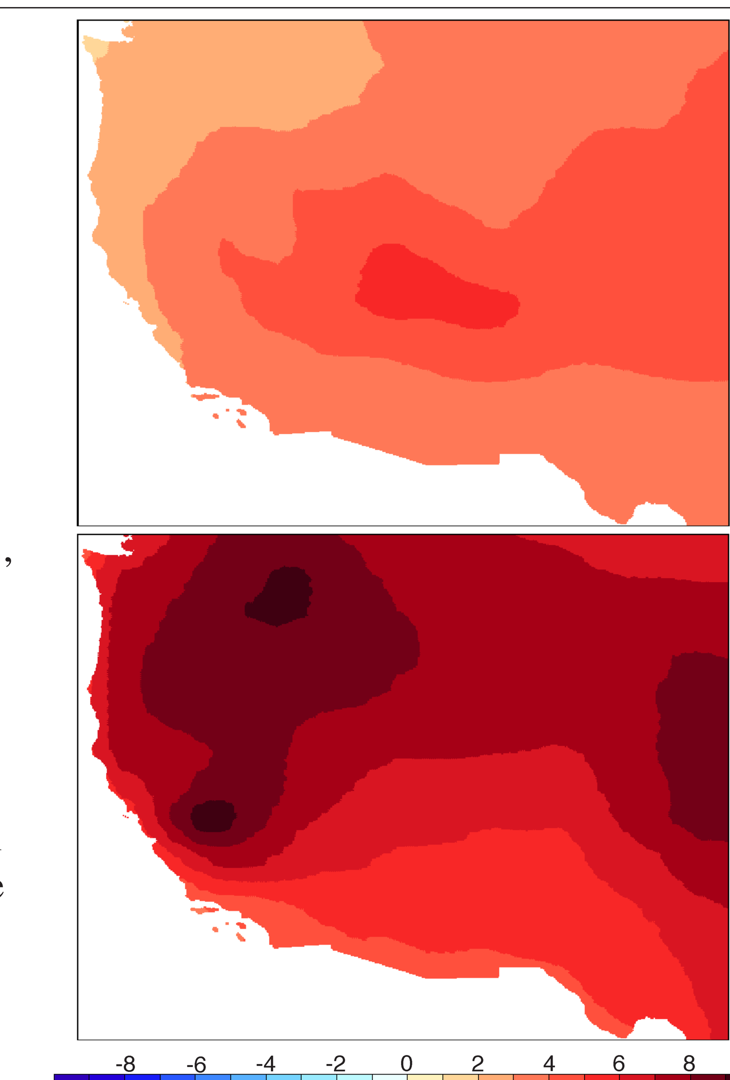
The Pacific Northwest study area and the The Nature Conservancy ecoregions (TNC 2006) intersecting Idaho, Oregon, and Washington. (Map: R. Pelltier, USGS)

1. Downscaled future climate simulations

We are using future climate simulations from five coupled atmosphere-ocean general circulation models. These data were produced for the World Climate Research Programme's Coupled Model Intercomparison Project phase 3 (CMIP3) and used in the recent Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4) initiative.

The global climate data are being downscaled to 2.5-minute (~5-km) and 30-arc-second (~1-km) grids of the study area. These fine spatial resolutions are important for resolving the effects of climate changes on mountainous regions, such as the Pacific Northwest. The downscaled future climate data will be produced at a monthly time-step and will cover the period 2010-2099.

Figure: Simulated changes for January (top) and July (bottom) 2070-2099 30-year mean annual temperatures as simulated by the UKMO-HadCM3 coupled atmosphere ocean general circulation model (Pope et al. 2000) for the western United States at a 2.5-minute resolution. The maps display future temperature changes as compared to the simulated 1961-1990 30-year mean climate representing current conditions. (Data: S. Shafer; Mapping and climate interpolation program: P. J. Bartlein, Univ. of Oregon)



2. Simulated future vegetation changes

The downscaled climate data will be used with dynamic vegetation models (e.g., LPJ, Sitch et al. 2003) to simulate future vegetation changes for the study area. These vegetation models simulate the distributions and productivity of plant functional types (PFTs), such as broadleaf deciduous trees or grass. The PFTs will be combined to define the major habitat types in the region, such as grassland or subalpine forest.

A key feature of these vegetation models is that they simulate the physiological responses of plants to changes in atmospheric CO_2 concentrations. Correctly modeling this response is important for simulating vegetation changes under future climates.

Future vegetation changes will be simulated at monthly and annual time-steps. The simulated vegetation data will be analyzed to identify the temporal and spatial patterns of vegetation changes, the emergence of new vegetation types that are not currently present in the region, and potential changes in the frequency and severity of drought and wildfires.

3. Simulated shifts in distributions of animal species

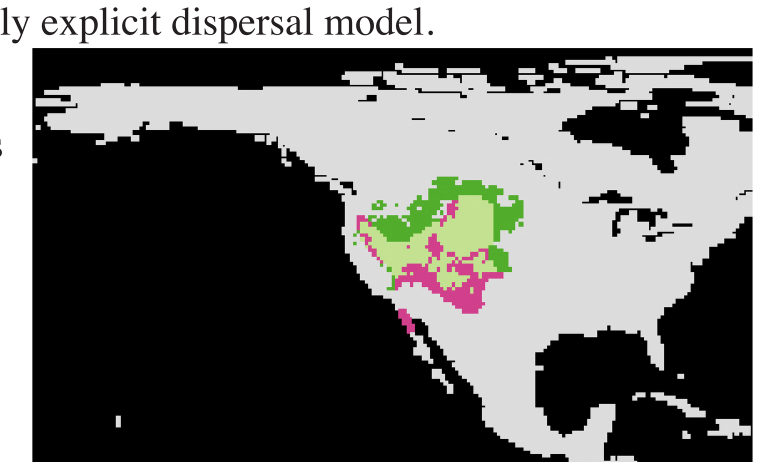
Changes in species distributions will be simulated in three phases:

Phase 1. We will use continental-scale machine-learning based bioclimatic models (Lawler et al. 2009) to predict future species distributions at a 50-km resolution across the study region.

Phase 2. Within the projected potential future ranges, we will project future distributions at a 30-second resolution using regional distribution models that take both changes in climate and changes in vegetation (habitat) into account.

Phase 3. We will simulate the potential movement of organisms through the changing landscapes using a spatially explicit dispersal model.

Figure: Pinyon Jay range projections (using the HADCM3 model and A2 emissions scenario for the years 2071-2099). Dark green indicates range expansion, light green indicates no range change, and red indicates range contraction. Adapted from J. Lawler (2010).



4. Assessing vulnerabilities

We will integrate the downscaled climate projections, projected vegetation changes, projected range shifts, and inherent species and system sensitivities to assess the relative vulnerability to climate change across the study region. These various assessments will be combined in several different ways to produce one or more indices of vulnerability for each species and for three types of managed lands: national parks, state and federal fish and wildlife refuges, and sites owned and managed by The Nature Conservancy.

Species and habitat sensitivities will be assessed using a climate change senstivity database being developed at the Univ. of Washington. For more information on the database, contact Joshua Lawler (jlawler@u.washington.edu) or Michael Case (mcase@u.washington.edu).

Greater sage-grouse (Photo: NPS)

5. Summarizing uncertainties

There are many different types of uncertainty associated with forecasts of future climate changes (Giorgi 2005) and the impacts that these changes will have on species and ecosystems. These uncertainties are not often explicitly described in climate-change studies, making it difficult for managers to determine how much they can rely on particular results. For this study, we will explicitly identify and describe many of the uncertainties associated with our models and analyses, enabling managers to better use the results of this study for decision-making and adaptive management. Examples of uncertainties that will be documented include:

- uncertainties associated with model simulations of particular variables
- temporal variability in uncertainty
- uncertainties created by variability among simulations
- uncertainties inherent in the vegetation and species distribution models
- uncertainties in vulnerability due to the subjective approach taken for combining elements of vulnerability into indices

6. Working with managers

We are collaborating with managers, scientists, and decision makers in state and federal agencies and NGOs to integrate the results of the vulnerability assessment (parts 1-5 on this poster) into management and conservation plans, such as the Idaho Comprehensive Wildlife Conservation Strategy (CWCS).

Meetings with managers will identify: 1) 'no-regrets' management actions for species and systems in the face of projected climatic changes, 2) the resource focal areas that are projected to experience the greatest climate-driven changes, and 3) areas where relationships with non-climatic stressors are most likely to result in the greatest impacts.

The results of this project will be presented at professional society meetings and climate change conferences. We will also produce reports and peer-reviewed articles targeted for managers. We anticipate that initial results from this project will be available in early 2011.

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